Scientific and Technical
Information Program

Click the ? icon for help

High Acceleration, High Life Cycle, Reusable In-Space Main Engine: 2000-2004

This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies for the crew exploration vehicle. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

Browse Subject Terms

Browse Corporate Sources

Browse Document Authors

Search for Text

PRINT

High Acceleration, High Life Cycle, Reusable In-Space Main Engine: 2000-2004

A Custom Bibliography From the
NASA Scientific and Technical Information Program

October 2004

High Acceleration, High Life Cycle, Reusable In-Space Main Engine: 2000-2004

This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies for the crew exploration vehicle. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

OCTOBER 2004

20040086006 NASA Marshall Space Flight Center, Huntsville, AL, USA

Liquid Metal Propellant Feed System for Plasma Propulsion

Markusic, T. E.; [2004]; In English, 11-14 Jul. 2004, Fort Lauderdale, FL, USA; No Copyright; Avail: Other Sources; Abstract Only

High-power plasma thrusters that utilize molten metallic propellants (e.g., the Lithium Lorentz Force Accelerator) are currently being investigated as a primary propulsion option for in-space nuclear-electric systems. A critical component of the thruster is the propellant feed system, which must reliably and accurately pump liquid metal into the thruster discharge chamber. We present design details and calibration results for a compact liquid metal propellant feed system that contains no moving parts, for use in laboratory testing of plasma thrusters. Feed line pressure is maintained using an MHD flow coupler, and the flow rate is monitored using a simple voltage divider, which is submerged in the propellant reservoir. Results for lithium and gallium propellants show capability to meter propellant at flow rates up to 10 +/- 0.1 mg/s.

Author

Plasma Propulsion; Propellants; Feed Systems; Liquid Metals; Lorentz Force; Lithium; Plasma Engines

20040066097 Virginia Univ., Charlottesville, VA, USA

Analysis of Factors Affecting the Performance of RLV Thrust Cell Liners

Arnold, Steven M., Technical Monitor; Butler, Daniel T., Jr.; Pinders, Marek-Jerzy; [2004]; In English

Contract(s)/Grant(s): NAG3-2359; No Copyright; Avail: CASI; A05, Hardcopy

The reusable launch vehicle (RLV) thrust cell liner, or thrust chamber, is a critical component of the Space Shuttle Main Engine (SSME). It is designed to operate in some of the most severe conditions seen in engineering practice. This requirement, in conjunction with experimentally observed 'dog-house' failure modes characterized by bulging and thinning of the cooling channel wall, provides the motivation to study the factors that influence RLV thrust cell liner performance. Factors or parameters believed to be directly related to the observed characteristic deformation modes leading to failure under in-service loading conditions are identified, and subsequently investigated using the cylindrical version of the higher-order theory for functionally graded materials in conjunction with the Robinson's unified viscoplasticity theory and the power-law creep model for modeling the response of the liner s constituents. Configurations are analyzed in which specific modifications in cooling channel wall thickness or constituent materials are made to determine the influence of these parameters on the deformations resulting in the observed failure modes in the outer walls of the cooling channel. The application of thermal barrier coatings and functional grading are also investigated within this context. Comparison of the higher-order theory results based on the Robinson and power-law creep model predictions has demonstrated that, using the available material parameters, the power-law creep model predicts more precisely the experimentally observed deformation leading to the 'dog-house' failure mode for multiple short cycles, while also providing much improved computational efficiency. However, for a single long cycle, both models predict virtually identical deformations. Increasing the power-law creep model coefficients produces appreciable deformations after just one long cycle that would normally be obtained after multiple cycles, thereby enhancing the efficiency of the analysis. This provides a basis for the development of an accelerated modeling procedure to further characterize dog-house deformation modes in RLV thrust cell liners. Additionally, the results presented herein have demonstrated that the mechanism responsible for deformation leading to 'dog-house' failure modes is driven by pressure, creep/relaxation and geometric effects.

Author (revised)

Reusable Launch Vehicles; Rocket Linings; Design Analysis; Thrust Chambers

20040048320

Fundamental Study of a Forward Laser Plasma Accelerator for Space Propulsion Applications

Kuramoto, Hideaki; Oyaizu, Keishi; Horisawa, Hideyuki; Kimura, Itsuro; AIP Conference Proceedings; March 30, 2004; ISSN 0094-243X; Volume 702, Issue no. 1, 493-502; In English; BEAMED ENERGY PROPULSION: Second International Symposium on Beamed Energy Propulsion, 20-23 October 2003, Sendai, Japan; Copyright

Compact accelerators employing laser-foil interactions which have significant potentials for space propulsion applications were reviewed. A feasibility study was conducted for the use of this phenomenon to primary propulsion applications. In order to evaluate thrust performance of this accelerator, time-gated imaging measurement with an ICCD camera was conducted for an Al foil target irradiated with an Nd:YAG laser set 1J/pulse with pulse width of 10nsec and wavelength of 1064nm. From the measurement, the maximum plasma speed was [approx] 100 km/sec. [copyright] 2004 American Institute of Physics

Author (AIP)

Electromagnetic Interactions; Infrared Spectra; Laser Applications; Laser Plasmas; Lasers; Plasma Accelerators; Plasma Heating; Plasmas (Physics); Propulsion; Spacecraft; Technology Utilization

20040045215 NASA Langley Research Center, Hampton, VA, USA

Next Generation Spacecraft, Crew Exploration Vehicle

January 2004; In English; No Copyright; Avail: CASI; A12, Hardcopy

This special bibliography includes research on reusable launch vehicles, aerospace planes, shuttle replacement, crew/cargo transfer vehicle, related X-craft, orbital space plane, and next generation launch technology.

Author

Aerospace Planes; Bibliographies; Reusable Launch Vehicles; Spacecrews; Technology Utilization; Hypersonic Vehicles; Space Shuttles; Launch Vehicle Configurations

20040027860 NASA Glenn Research Center, Cleveland, OH, USA, Ohio Aerospace Inst., Cleveland, OH, USA

NASA GRC High Power Electromagnetic Thruster Program

LaPointe, Michael R.; Pensil, Eric J.; October 03, 2004; In English, 8-12 Feb. 2004, Albuquerque, NM, USA

Contract(s)/Grant(s): NCC3-860; WBS 22-755-70-07

Report No.(s): STAIF-086; No Copyright; Avail: CASI; A03, Hardcopy

High-power electromagnetic thrusters have been proposed as primary in-space propulsion options for several bold new interplanetary and deep-space missions. As the lead center for electric propulsion, the NASA Glenn Research Center designs, develops, and tests high-power electromagnetic technologies to meet these demanding mission requirements. Two high-power thruster concepts currently under investigation by Glenn are the magnetoplasmadynamic (MPD) thruster and the Pulsed Inductive Thruster (PIT). This paper describes the MPD thruster and the test facility.

Author (revised)

Magnetoplasmadynamic Thrusters; Test Facilities

20040020177

NASA GRC High Power Electromagnetic Thruster Program

LaPointe, Michael R.; Pencil, Eric J.; AIP Conference Proceedings; February 04, 2004; ISSN 0094-243X; Volume 699, Issue no. 1, 388-398; In English; SPACE TECHNOLOGY and APPLICATIONS INTERNAT. FORUM-STAIF 2004: Conf.on Thermophys.in Microgravity; Commercial/Civil Next Gen.Space Transp.; 21st Symp.Space Nuclear Power & Propulsion; Human Space Explor.; Space Colonization; New Frontiers & Future Concepts, 8-11 February 2004, Albuquerque, New Mexico, USA; Copyright

Interest in high power electromagnetic propulsion has been revived to support a variety of future space missions, such as platform maneuvering in low earth orbit, cost-effective cargo transport to lunar and Mars bases, asteroid and outer planet sample return, deep space robotic exploration, and piloted missions to Mars and the outer planets. Magnetoplasmadynamic (MPD) thrusters have demonstrated, at the laboratory level, the capacity to process megawatts of electrical power while providing higher thrust densities than current electric propulsion systems. The ability to generate higher thrust densities permits a reduction in the number of thrusters required to perform a given mission and alleviates the system complexity associated with multiple thruster arrays. The specific impulse of an MPD thruster can be optimized to meet given mission requirements, from a few thousand seconds with heavier gas propellants up to 10,000 seconds with hydrogen propellant. In support of NASA space science and human exploration strategic initiatives, Glenn Research Center is developing and testing pulsed, MW-class MPD thrusters as a prelude to long-duration high power thruster tests. The research effort includes

numerical modeling of self-field and applied-field MPD thrusters and experimental testing of quasi-steady MW-class MPD thrusters in a high power pulsed thruster facility. This paper provides an overview of the GRC high power electromagnetic thruster program and the pulsed thruster test facility. [copyright] 2004 American Institute of Physics
Author (AIP)
Asteroid Missions; Cost Effectiveness; Deep Space; Electric Generators; Electric Propulsion; Electromagnetic Propulsion; Gas Giant Planets; Grand Tours; Ion Engines; Low Earth Orbits; Lunar Bases; Magnetohydrodynamics; Mars (Planet); Mars Bases; Mars Missions; Plasmas (Physics); Propulsion; Research Projects; Sample Return Missions; Space Exploration; Space Missions; Spacecraft; Spacecraft Power Supplies

20040012729 NASA Marshall Space Flight Center, Huntsville, AL, USA
Space Shuttle Main Engine Implications for the Abort-to-Orbit Off-the-Pad Study
Schoffstoll, Dayna L.; [2003]; In English, 1 Dec. 2003, Colorado Springs, CO, USA; No Copyright; Avail: Other Sources; Abstract Only

In 2001, the Space Shuttle Main Engine (SSME) project office was contacted by the Space Shuttle Ascent Guidance, Navigation, and Control group to provide the engine perspective for an Abort-to-Orbit (ATO) study. The purpose of the AT0 Off-the-Pad study was to determine the feasibility of eliminating the Return to Launch Site and Transatlantic abort modes by using a five-segment solid rocket booster and throttling the remaining SSMEs to a higher power level. This would enable all abort modes to be Abort-to-Orbit. The SSME project office at Marshall Space Flight Center collaborated with MSFC's Space Transportation Directorate and Rocketdyne Propulsion and Power to provide the AT0 Off-the-Pad study with the analysis required. Power levels at 109%, 1 11% and 1 13% of rated power level were studied as well as mixture ratio decreases down to 5.85. SSME was to evaluate and define the technical and programmatic impacts to certify the SSME to these abort power levels. The SSME systems analysis group performed a steady state analysis using the SSME power balance model to determine if there were any technical issues associated with higher power level, low mixture ratio operation. Based on each power level/mixture ratio combination, an engine certification plan was created and a preliminary probabilistic risk assessment was performed. The results showed favorable results for higher power 1evel/lower mixture ratio SSME operation. In nearly all performance and redline parameters, the traded engine operation was encompassed by nominal engine performance of a prior engine configuration.
Author
Space Shuttle Main Engine; Space Shuttle Boosters

20030111910 NASA Marshall Space Flight Center, Huntsville, AL, USA
Operational Issues in the Development of a Cost-Effective Reusable LOX/LH2 Engine
Ballard, Richard O.; October 10, 2003; In English, 27-30 Oct. 2003, Chattanooga, TN, USA; No Copyright; Avail: CASI; A02, Hardcopy

The NASA Space Launch Initiative (SLI) was initiated in early 2001 to conduct technology development and to reduce the business and technical risk associated with developing the next-generation reusable launch system. In the field of main propulsion, two LOXLH2 rocket engine systems, the Pratt & Whitney / Aerojet Joint Venture (JV) COBRA and the Rocketdyne RS-83, were funded to develop a safe, economical, and reusable propulsion system. Given that a large-thrust reusable rocket engine program had not been started in the U.S. since 1971, with the Space Shuttle Main Engine (SSME), this provided an opportunity to build on the experience developed on the SSME system, while exploiting advances in technology that had occurred in the intervening 30 years. One facet of engine development that was identified as being especially vital in order to produce an optimal system was in the areas of operability and maintainability. In order to achieve the high levels of performance required by the Space Shuttle, the SSME system is highly complex with very tight tolerances and detailed requirements. Over the lifetime of the SSME program, the engine has required a high level of manpower to support the performance of inspections, maintenance (scheduled and unscheduled) and operations (prelaunch and post-flight). As a consequence, the labor- intensive needs of the SSME provide a significant impact to the overall cost efficiency of the Space Transportation System (STS). One of the strategic goals of the SLI is to reduce cost by requiring the engine(s) to be easier (Le. less expensive) to operate and maintain. The most effective means of accomplishing this goal is to infuse the operability and maintainability features into the engine design from the start. This paper discusses some of the operational issues relevant to a reusable LOx/LH2 main engine, and the means by which their impact is mitigated in the design phase.
Author
Technology Assessment; Reusable Rocket Engines; Spacecraft Launching; Cost Reduction

20030111806 Ohio Aerospace Inst., Brook Park, OH, USA

Megawatt Electromagnetic Plasma Propulsion

Gilland, James; Lapointe, Michael; Mikellides, Pavlos; June 9, 2003; In English, 9-10 Jun. 2003, Lerici, Italy
Contract(s)/Grant(s): NCC3-860; No Copyright; Avail: CASI; A03, Hardcopy

The NASA Glenn Research Center program in megawatt level electric propulsion is centered on electromagnetic acceleration of quasi-neutral plasmas. Specific concepts currently being examined are the Magnetoplasmadynamic (MPD) thruster and the Pulsed Inductive Thruster (PIT). In the case of the MPD thruster, a multifaceted approach of experiments, computational modeling, and systems-level models of self field MPD thrusters is underway. The MPD thruster experimental research consists of a 1-10 MWe, 2 ms pulse-forming-network, a vacuum chamber with two 32 diffusion pumps, and voltage, current, mass flow rate, and thrust stand diagnostics. Current focus is on obtaining repeatable thrust measurements of a Princeton Benchmark type self field thruster operating at 0.5-1 gls of argon. Operation with hydrogen is the ultimate goal to realize the increased efficiency anticipated using the lighter gas. Computational modeling is done using the MACH2 MHD code, which can include real gas effects for propellants of interest to MPD operation. The MACH2 code has been benchmarked against other MPD thruster data, and has been used to create a point design for a 3000 second specific impulse (Isp) MPD thruster. This design is awaiting testing in the experimental facility. For the PIT, a computational investigation using MACH2 has been initiated, with experiments awaiting further funding. Although the calculated results have been found to be sensitive to the initial ionization assumptions, recent results have agreed well with experimental data. Finally, a systems level self-field MPD thruster model has been developed that allows for a mission planner or system designer to input Isp and power level into the model equations and obtain values for efficiency, mass flow rate, and input current and voltage. This model emphasizes algebraic simplicity to allow its incorporation into larger trajectory or system optimization codes. The systems level approach will be extended to the pulsed inductive thruster and other electrodeless thrusters at a future date.
Derived from text

Electromagnetic Propulsion; Plasma Propulsion; Magnetoplasmadynamic Thrusters; Mathematical Models

20030090559

An overview of MEMS-based micropropulsion developments at JPL

Mueller, Juergen; Marrese, Colleen; Polk, James; Yang, Eui-Hyeok; Green, Amanda; White, Victor; Bame, David; Chadraborty, Indrani; Vargo, Stephen; Reinicke, Robert; Acta Astronautica; May/June 2003; ISSN 0094-5765; Volume 52, Issue no. 9-12, p. 881-895; In English; Copyright; Avail: Other Sources

Development of MEMS (Microelectromechanical Systems) micropropulsion at the Jet Propulsion Laboratory (JPL) is reviewed. This includes a vaporizing liquid micro-thruster for microspacecraft attitude control, a micro-ion engine for microspacecraft primary propulsion or large spacecraft fine attitude control, as well as several valve studies, including a solenoid valve studied in collaboration with Moog Space Products Division, and a piezoelectric micro-valve. The solenoid valve features much faster actuation (as little as 1.5 ms to open) than commercially available MEMS valves and showed no detectable leak (less than 10(sup -4) sccs GN(sub 2)) even after 1 million cycles. The solenoid valve weighs 7 gram and is about 1 cm(sup 3). A micro-isolation valve, aimed at sealing propulsion systems at zero leak rates, was able to show burst pressures as high as 3,000 psi even though entirely machined from silicon and Pyrex. It could be actuated with energies as little as 0.1 mJ. (copyright) 2003 Published by Elsevier Science Ltd.
EI

Electromechanical Devices; Low Thrust Propulsion; Microelectromechanical Systems; Piezoelectricity; Propulsion; Solenoids; Spacecraft; Spacecraft Propulsion

20030067417 NASA Marshall Space Flight Center, Huntsville, AL, USA

High-Energy Two-Stage Pulsed Plasma Thruster

Markusic, Tom; [2003]; In English, 20-23 Jul. 2003, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

A high-energy (28 kJ per pulse) two-stage pulsed plasma thruster (MSFC PPT-1) has been constructed and tested. The motivation of this project is to develop a high power (approximately 500 kW), high specific impulse (approximately 10000 s), highly efficient (greater than 50%) thruster for use as primary propulsion in a high power nuclear electric propulsion system. PPT-1 was designed to overcome four negative characteristics which have detracted from the utility of pulsed plasma thrusters: poor electrical efficiency, poor propellant utilization efficiency, electrode erosion, and reliability issues associated with the use of high speed gas valves and high current switches. Traditional PPTs have been plagued with poor efficiency because they have not been operated in a plasma regime that fully exploits the potential benefits of pulsed plasma acceleration by electromagnetic forces. PPTs have generally been used to accelerate low-density plasmas with long current pulses. Operation of thrusters in this plasma regime allows for the development of certain undesirable particle-kinetic effects, such

as Hall effect-induced current sheet canting. PPT-1 was designed to propel a highly collisional, dense plasma that has more fluid-like properties and, hence, is more effectively pushed by a magnetic field. The high-density plasma loading into the second stage of the accelerator is achieved through the use of a dense plasma injector (first stage). The injector produces a thermal plasma, derived from a molten lithium propellant feed system, which is subsequently accelerated by the second stage using mega-amp level currents, which eject the plasma at a speed on the order of 100 kilometers per second. Traditional PPTs also suffer from dynamic efficiency losses associated with snowplow loading of distributed neutral propellant. The twostage scheme used in PPT-I allows the propellant to be loaded in a manner which more closely approximates the optimal slug loading. Lithium propellant was chosen to test whether or not the reduced electrode erosion found in the Lithium Lorentz Force Accelerator (LiLFA) could also be realized in a pulsed plasma thruster. The use of the molten lithium dense plasma injector also eliminates the need for a gas valve and electrical switch; the injector design fulfills both roles, and uses no moving parts to provide, in principle, a highly reliable propellant feed and electrical switching system. Experimental results reported in this paper include: second-stage current traces, high-speed photographic and holographic imaging of the thruster exit plume, and internal mapping of the discharge chamber magnetic field from B-dot probe data. The magnetic field data is used to create a two-dimensional description of the evolution of the current sheet inside the thruster.
Author

High Speed; Magnetic Fields; Plasma Acceleration; Plasmas (Physics); Pulsed Plasma Thrusters; Nuclear Electric Propulsion

20030066142 Boeing Co., Canoga Park, CA, USA

RS-84 Engine

Stegman, E.; March 20, 2003; In English, Jul. 2003, Huntsville, AL, USA

Contract(s)/Grant(s): NAS8-01107; No Copyright; Avail: Other Sources; Abstract Only

The RS-84 is the first reusable hydrocarbon staged combustion liquid rocket engine. This engine is being developed to meet NASA s crew safety goals with a highly reliable and low cost main engine as a part of the NASA Space Launch Initiative program for the next generation reusable launch system. The NASA-MSFC and Rocketdyne team brings over 50 years of successful rocket engine development experience to meet the challenges of this new program. This team s extensive design database has been anchored with almost five decades of hydrocarbon rocket engine development and flight operations experience including Delta, Atlas, and Saturn vehicles and nearly three decades of successfully operating the world s only reusable pump-fed rocket engine, the Space Shuttle Main Engine. The team also fully benefits from the proven and experienced engineering staffs that recently completed the successful MC-1 FASTRAC , XRS-2200, and RS-68 engine development programs and the ongoing IPD and RS-76 technology development. Advances in integrated parametric design and analysis tools, advanced materials knowledge base, and state-of-the-art fabrication processes anchored and refined during the recent engine development programs are already being used by the team to design this engine.
Author

Reusable Rocket Engines; Hydrocarbon Combustion

20030064034 NASA Marshall Space Flight Center, Huntsville, AL, USA

Shuttle Main Propulsion System LH2 Feed Line and Inducer Simulations

Dorney, Daniel J.; Rothermel, Jeffry; [2002]; In English, 19-21 Nov. 2002, Huntsville, AL, USA; No Copyright; Avail: CASI; A03, Hardcopy

This viewgraph presentation includes simulations of the unsteady flow field in the LH2 feed line, flow line, flow liner, backing cavity and inducer of Shuttle engine #1. It also evaluates aerodynamic forcing functions which may contribute to the formation of the cracks observed on the flow liner slots. The presentation lists the numerical methods used, and profiles a benchmark test case.
CASI

Space Shuttle Main Engine; Liquid Hydrogen; Feed Systems; Flow Distribution

20030059609

Plasma Fluctuations in an Applied Field MPD Thruster

Antoni, V.; Bagatin, M.; Serianni, G.; Vianello, N.; Zuin, M.; Paganucci, F.; Rossetti, P.; Andrenucci, M.; AIP Conference Proceedings; June 11, 2003; ISSN 0094-243X; Volume 669, Issue no. 1, 302-305; In English; PLASMA PHYSICS: 11th International Congress on Plasma Physics: ICPP2002, 15-19 July 2002, Sydney, Australia; Copyright

The mean values of electron temperature and density in the plume of a gas-fed, externally applied field, Magneto-Plasma

Dynamic (MPD) thruster, have been measured with a balanced triple probe. The spatial distribution and the temporal behaviour of floating potential fluctuations have been also investigated using multielectrode probes. The addition of an external magnetic field results in an increase of the fluctuation levels of electron temperature, density and floating potential. Mean values in the anode region at the thruster outlet have been related to the Hall parameter to understand the Hall current's contribution to the thrust. Spectral analysis of the floating potential fluctuations shows the importance of the external magnetic field in the dynamic of plasma instabilities. [copyright] 2003 American Institute of Physics
Author (AIP)
Electric Propulsion; Electron Density (Concentration); Electron Energy; Electrons; Gas Density; Magnetohydrodynamics; Magnetoplasmadynamic Thrusters; Plasma Density; Plasma Physics; Plasmas (Physics); Temperature

20030051653

Fundamental Study of a Relativistic Laser-Accelerated Plasma Thruster

Horisawa, Hideyuki; Kuramoto, Hideaki; Oyaizu, Keishi; Uchida, Naoki; Kimura, Itsuro; AIP Conference Proceedings; May 14, 2003; ISSN 0094-243X; Volume 664, Issue no. 1, 411-422; In English; BEAMED ENERGY PROPULSION: First International Symposium on Beamed Energy Propulsion, 5-7 November 2002, Huntsville, Alabama, USA; Copyright

Potential concepts of laser-accelerators which can be applied to the spacecraft propulsion using a conventional technique were reviewed. Maximum ion energy of order tens of MeV through the acceleration was reported in recent studies. As for a proton beam accelerated up to 58 MeV, which was achieved in a recent study, its speed corresponds to 33 % of the speed of light and the specific impulse of order 107 sec. Also, a feasibility study of the utilization of these accelerators, based on the special theory of relativity, for space propulsion was conducted. It was shown that significantly high specific impulse can be obtained through this propulsion system for primary propulsion and attitude control applications. In addition, a preliminary experiment was conducted with an ultrashort-pulse laser system. Induced impulse in the forward acceleration mode was observed using a 12-[mu]m thick Al foil as a target. [copyright] 2003 American Institute of Physics
Author (AIP)
Electric Propulsion; Laser Applications; Laser Beams; Laser Plasmas; Lasers; Plasmas (Physics); Relativistic Plasmas; Spacecraft; Spacecraft Propulsion

20030006821

MW-Class Thruster Experiments at NASA GRC

LaPointe, Michael R.; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 525-532; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright

As the lead NASA center for electric propulsion, the Glenn Research Center is developing MW-class electric thrusters to meet a variety of future mission applications. A pulsed, high power MPD thruster test facility has been established at GRC, and preliminary voltage-current measurements have been obtained with a MW-class baseline thruster design. Fabrication and testing of a flexure based thrust stand are being completed, and the stand is expected to be in service in the near future. The combined measurements of thrust, voltage, and current will provide sufficient information to determine thruster efficiency, and the near-term goal of the GRC test program is to design and demonstrate gas-fed MPD thrusters with efficiencies in excess of 50%. The close collaboration between modeling and experiment is anticipated to lead to the development of more efficient MW-class MPD thrusters that are capable of meeting the diverse and demanding in-space propulsion requirements envisioned by NASA mission planners. [copyright] 2003 American Institute of Physics
Author (AIP)
Electric Propulsion; Electrical Properties; Magnetic Fields; Magnetohydrodynamic Flow; Plasmas (Physics); Spacecraft Propulsion; Test Facilities

20030006820

MPD Thruster Performance Analytic Models

Gilland, James; Johnston, Geoffrey; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 516-524; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright

Magnetoplasmadynamic (MPD) thrusters are capable of accelerating quasi-neutral plasmas to high exhaust velocities

using Megawatts (MW) of electric power. These characteristics make such devices worthy of consideration for demanding, far-term missions such as the human exploration of Mars or beyond. Assessment of MPD thrusters at the system and mission level is often difficult due to their status as ongoing experimental research topics rather than developed thrusters. However, in order to assess MPD thrusters' utility in later missions, some adequate characterization of performance, or more exactly, projected performance, and system level definition are required for use in analyses. The most recent physical models of self-field MPD thrusters have been examined, assessed, and reconfigured for use by systems and mission analysts. The physical models allow for rational projections of thruster performance based on physical parameters that can be measured in the laboratory. The models and their implications for the design of future MPD thrusters are presented. [copyright] 2003 American Institute of Physics
Author (AIP)
Electric Propulsion; Exhaust Velocity; Magnetic Fields; Magnetohydrodynamic Flow; Magnetoplasmadynamic Thrusters; Mathematical Models; Models; Performance Prediction; Plasmas (Physics); Spacecraft Propulsion

20030005845 NASA Marshall Space Flight Center, Huntsville, AL USA
Understanding and Resolution of the Block 2 SSME, STS-104 Engine Shutdown Pressure Surge In-Flight Anomaly
Greene, William D.; Kynard, Michael H.; Tiller, Bruce K., Technical Monitor; Jul. 07, 2002; In English; 38th AIAA/ASME/SAE/ASEE Joint Propulsion Conference and Exhibit, 7-10 Jul. 2002, Indianapolis, IN, USA; Original contains color illustrations
Report No.(s): AIAA Paper 2002-3581; No Copyright; Avail: CASI; A03, Hardcopy; Distribution under U.S. Government purpose rights

STS-104, launched July 2001, marked the first flight of a single Block 2 Space Shuttle Main Engine (SSME). This new configuration of the SSME is the culmination of well over a decade of gradual engine system upgrades. The launch and mission were a success. However, in the process of post-launch data analysis a Main Propulsion System (MPS) anomaly was noted and tied directly to the shutdown of the Block 2 SSME. An investigation into this anomaly was organized across NASA facilities and across the various hardware component contractors. This paper is a very brief summary of the eventual understanding of the root causes of the anomaly and the process whereby an appropriate mitigation action was proposed. An analytical model of the High Pressure Fuel Pump (HPFP) and the low pressure fuel system of the SSME is presented to facilitate the presentation of this summary. The proposed mitigation action is discussed and, with the launch of STS-108 in November 2001, successfully demonstrated under flight conditions.
Author
Anomalies; Flight Conditions; Fuel Systems; Mathematical Models; Shutdowns; Space Shuttle Main Engine

20030001957 Air Force Research Lab., Edwards AFB, CA USA
Powersail High Power Propulsion System Design Study
Gulczinski, Frank S., III; Nov. 2000; In English
Contract(s)/Grant(s): Proj-6340
Report No.(s): AD-A407953; AFRL-PR-ED-AB-2000-219; AFRL-PR-ED-AB-2000-219; No Copyright; Avail: CASI; A01, Hardcopy

A desire by the USA Air Force to exploit the space environment has led to a need for increased on-orbit electrical power availability. To enable this, the Air Force Research Laboratory Space Vehicles Directorate (AFRL/ VS) is developing Powersail: a two-phased program to demonstrate high power (100 kW to 1 MW) capability in space using a deployable, flexible solar array connected to the host spacecraft using a slack umbilical. The first phase will be a proof-of-concept demonstration at 50 kW, followed by the second phase, an operational system at full power. In support of this program, the AFRL propulsion Directorate's Spacecraft Propulsion Branch (AFRL/PRS) at Edwards AFB has commissioned a design study of the Powersail High Power Propulsion System. The purpose of this study, the results of which are summarized in this paper, is to perform mission and design trades to identify potential full-power applications (both near-Earth and interplanetary) and the corresponding propulsion system requirements and design. The design study shall farther identify a suitable low power demonstration flight that maximizes risk reduction for the fully operational system. This propulsion system is expected to be threefold: (1) primary propulsion for moving the entire vehicle, (2) a propulsion unit that maintains the solar array position relative to the host spacecraft, and (3) control propulsion for maintaining proper orientation for the flexible solar array.
DTIC
Solar Arrays; Solar Propulsion; Spacecraft Propulsion

20020087937 NASA Marshall Space Flight Center, Huntsville, AL USA
Design of a High-Energy, Two-Stage Pulsed Plasma Thruster
Markusic, T. E.; Thio, Y. C. F.; Cassibry, J. T.; Rodgers, Stephen L., Technical Monitor; [2002]; In English; 38th AIAA Joint Propulsion Conference, 7-10 Jul. 2002, Indianapolis, IN, USA
Report No.(s): AIAA Paper 2002-4125; Copyright; Avail: CASI; A03, Hardcopy; Distribution as joint owner in the copyright

Design details of a proposed high-energy (approx. 50 kJ/pulse), two-stage pulsed plasma thruster are presented. The long-term goal of this project is to develop a high-power (approx. 500 kW), high specific impulse (approx. 7500 s), highly efficient (approx. 50%),and mechanically simple thruster for use as primary propulsion in a high-power nuclear electric propulsion system. The proposed thruster (PRC-PPT1) utilizes a valveless, liquid lithium-fed thermal plasma injector (first stage) followed by a high-energy pulsed electromagnetic accelerator (second stage). A numerical circuit model coupled with one-dimensional current sheet dynamics, as well as a numerical MHD simulation, are used to qualitatively predict the thermal plasma injection and current sheet dynamics, as well as to estimate the projected performance of the thruster. A set of further modelling efforts, and the experimental testing of a prototype thruster, is suggested to determine the feasibility of demonstrating a full scale high-power thruster.
Author
Thermal Plasmas; Pulsed Plasma Thrusters; Metallic Plasmas; Design Analysis

20020085154 NASA Marshall Space Flight Center, Huntsville, AL USA
COBRA Main Engine Project
Snoddy, Jim; Sides, Steve; Lyles, Garry M., Technical Monitor; [2002]; In English; 1st AIAA/IAF Symposium on Future Reusable Launch Vehicles, 12 Apr. 2002, Huntsville, AL, USA
Contract(s)/Grant(s): NAS8-01108; No Copyright; Avail: CASI; A03, Hardcopy

The COBRA (CO-Optimized Booster for Reusable Applications) project include the following: 1. COBRA main engine project team. 2. COBRA and RLX cycles selected. 3. COBRA proto-type engine approach enables mission success. 4. COBRA provides quick, low cost demo of cycle and technologies. 5. COBRA cycle I risk reduction supports. 6. Achieving engine safety. 6. RLX cycle I risk reduction supports. 7. Flight qualification. 9. Life extension engine testing.
CASI
Engine Tests; Booster Rocket Engines; Reusable Rocket Engines; Design Analysis

20020046693 Boeing Co., Canoga Park, CA USA
Space Shuttle Main Engine: Thirty Years of Innovation
Jue, F. H.; Hopson, George, Technical Monitor; [2002]; In English; 6th Propulsion for Space Transportation Symposium, 15 May 2002, Versailles, France
Contract(s)/Grant(s): NAS8-45000; No Copyright; Avail: CASI; A01, Hardcopy

The Space Shuttle Main Engine (SSME) is the first reusable, liquid booster engine designed for human space flight. This paper chronicles the 30-year history and achievements of the SSME from authority to proceed up to the latest flight configuration - the Block 2 SSME.
Author
Booster Rocket Engines; Space Shuttle Main Engine; Histories

20020020169 NASA Marshall Space Flight Center, Huntsville, AL USA
Unsteady Flow in a Supersonic Turbine with Variable Specific Heats
Dorney, Daniel J.; Griffin, Lisa W.; Huber, Frank; Sondak, Douglas L.; Turner, James, Technical Monitor; [2001]; In English; Copyright; Avail: CASI; A03, Hardcopy

Modern high-work turbines can be compact, transonic, supersonic, counter-rotating, or use a dense drive gas. The vast majority of modern rocket turbine designs fall into these Categories. These turbines usually have large temperature variations across a given stage, and are characterized by large amounts of flow unsteadiness. The flow unsteadiness can have a major impact on the turbine performance and durability. For example, the Space Transportation Main Engine (STME) fuel turbine, a high work, transonic design, was found to have an unsteady inter-row shock which reduced efficiency by 2 points and increased dynamic loading by 24 percent. The Revolutionary Reusable Technology Turbopump (RRTT), which uses full flow oxygen for its drive gas, was found to shed vortices with such energy as to raise serious blade durability concerns. In both cases, the sources of the problems were uncovered (before turbopump testing) with the application of validated, unsteady computational fluid dynamics (CFD) to the designs. In the case of the RRTT and the Alternate Turbopump Development

(ATD) turbines, the unsteady CFD codes have been used not just to identify problems, but to guide designs which mitigate problems due to unsteadiness. Using unsteady flow analyses as a part of the design process has led to turbine designs with higher performance (which affects temperature and mass flow rate) and fewer dynamics problems. One of the many assumptions made during the design and analysis of supersonic turbine stages is that the values of the specific heats are constant. In some analyses the value is based on an average of the expected upstream and downstream temperatures. In stages where the temperature can vary by 300 to 500 K, however, the assumption of constant fluid properties may lead to erroneous performance and durability predictions. In this study the suitability of assuming constant specific heats has been investigated by performing three-dimensional unsteady Navier-Stokes simulations for a supersonic turbine stage.

Derived from text

Supersonic Turbines; Unsteady Flow; Specific Heat; Computational Fluid Dynamics; Three Dimensional Models

20010094060 NASA Glenn Research Center, Cleveland, OH USA

High Power MPD Thruster Development at the NASA Glenn Research Center

LaPointe, Michael R.; Mikellides, Pavlos G.; Reddy, Dhanireddy, Technical Monitor; August 2001; In English; 37th Joint Propulsion Conference and Exhibit, 8-11 Jul. 2001, Salt Lake City, UT, USA

Contract(s)/Grant(s): NCC3-860; RTOP 755-B4-07

Report No.(s): NASA/CR-2001-211114; E-12961; NAS 1.26:211114; AIAA Paper 2001-3499; No Copyright; Avail: CASI; A03, Hardcopy

Propulsion requirements for large platform orbit raising, cargo and piloted planetary missions, and robotic deep space exploration have rekindled interest in the development and deployment of high power electromagnetic thrusters. Magnetoplasmadynamic (MPD) thrusters can effectively process megawatts of power over a broad range of specific impulse values to meet these diverse in-space propulsion requirements. As NASA's lead center for electric propulsion, the Glenn Research Center has established an MW-class pulsed thruster test facility and is refurbishing a high-power steady-state facility to design, build, and test efficient gas-fed MPD thrusters. A complimentary numerical modeling effort based on the robust MACH2 code provides a well-balanced program of numerical analysis and experimental validation leading to improved high power MPD thruster performance. This paper reviews the current and planned experimental facilities and numerical modeling capabilities at the Glenn Research Center and outlines program plans for the development of new, efficient high power MPD thrusters.

Author

Electromagnetic Propulsion; Plasma Propulsion; Magnetoplasmadynamic Thrusters; Rocket Test Facilities; Mathematical Models; Research Facilities

20010020088 Boeing Co., USA

Space Shuttle Main Engine Joint Data List Applying Today's Desktop Technologies to Facilitate Engine Processing

Jacobs, Kenneth; Drobnick, John; Krell, Don; Neuhart, Terry; McCool, A., Technical Monitor; [2001]; In English, March 2001, Orlando, FL, USA

Contract(s)/Grant(s): NAS8-45000; No Copyright; Avail: Other Sources; Abstract Only

Boeing-Rocketdyne's Space Shuttle Main Engine (SSME) is the world's first large reusable liquid rocket engine. The space shuttle propulsion system has three SSMEs, each weighing 7,400 lbs and providing 470,000 lbs of thrust at 100% rated power level. To ensure required safety and reliability levels are achieved with the reusable engines, each SSME is partially disassembled, inspected, reassembled, and retested at Kennedy Space Center between each flight. Maintenance processing must be performed very carefully to replace any suspect components, maintain proper engine configuration, and avoid introduction of contaminants that could affect performance and safety. The long service life, and number, complexity, and pedigree of SSME components makes logistics functions extremely critical. One SSME logistics challenge is documenting the assembly and disassembly of the complex joint configurations. This data (joint nomenclature, seal and fastener identification and orientation, assembly sequence, fastener torques, etc.) must be available to technicians and engineers during processing. Various assembly drawings and procedures contain this information, but in this format the required (practical) joint data can be hard to find, due to the continued use of archaic engineering drawings and microfilm for field site use. Additionally, the release system must traverse 2,500 miles between design center and field site, across three time zones, which adds communication challenges and time lags for critical engine configuration data. To aid in information accessibility, a Joint Data List (JDL) was developed that allows efficient access to practical joint data. The published JDL has been a very useful logistics product, providing illustrations and information on the latest SSME configuration. The JDL identifies over 3,350 unique parts across seven fluid systems, over 300 joints, times two distinct engine configurations. The JDL system was recently converted to a web-based, navigable electronic manual that contains all the required data and illustrations in expanded view format using

standard PC products (Word, Excel, PDF, Photoshop). The logistics of accurately releasing this information to field personnel was greatly enhanced via the utilization of common office products to produce a more user-friendly format than was originally developed under contract to NASA. This was done without reinventing the system, which would be cost prohibitive on a program of this maturity. The brunt of the joint part tracking is done within the logistics organization and disseminated to all field sites, without duplicating effort at each site. The JDL is easily accessible across the country via the NASA intranet directly at the SSME workstand. The advent of this logistics data product has greatly enhanced the reliability of tracking dynamic changes to the SSME and greatly reduces engineering change turnaround time and potential for errors. Since the inception of the JDL system in 1997, no discrepant parts have propagated to engine assembly operations. This presentation focuses on the challenges overcome and the techniques used to apply today's desktop technologies to an existing logistics data source.
Author
Space Shuttle Main Engine; Engineering Drawings; Logistics; Maintenance; Lists

20010016102 NASA Glenn Research Center, Cleveland, OH USA
Mission Advantages of Constant Power, Variable Isp Electrostatic Thrusters
Oleson, Steven R.; November 2000; In English; 36th, 16-19 Jul. 2000, Huntsville, AL, USA
Contract(s)/Grant(s): RTOP 632-6B-1C
Report No.(s): NASA/TM-2000-210477; E-12473; NAS 1.15:210477; AIAA Paper 2000-3413; No Copyright; Avail: CASI; A03, Hardcopy

Electric propulsion has moved from station-keeping capability for spacecraft to primary propulsion with the advent of both the Deep Space One asteroid flyby and geosynchronous spacecraft orbit insertion. In both cases notably more payload was delivered than would have been possible with chemical propulsion. To provide even greater improvements electrostatic thruster performance could be varied in specific impulse, but kept at constant power to provide better payload or trip time performance for different mission phases. Such variable specific impulse mission applications include geosynchronous and low earth orbit spacecraft stationkeeping and orbit insertion, geosynchronous reusable tug missions, and interplanetary probes. The application of variable specific impulse devices is shown to add from 5 to 15% payload for these missions. The challenges to building such devices include variable voltage power supplies and extending fuel throughput capabilities across the specific impulse range.
Author
Electrostatic Propulsion; Specific Impulse; Propulsion System Performance; Trajectory Planning

20000096499 NASA Marshall Space Flight Center, Huntsville, AL USA
Thermographic Nondestructive Evaluation of the Space Shuttle Main Engine Nozzle
Walker, James L.; Lansing, Matthew D.; Russell, Samuel S.; Caraccioli, Paul; Whitaker, Ann F., Technical Monitor; [2000]; In English; 4th Aerospace Materials, Processes and Environmental Technology, 18-20 Sep. 2000, Huntsville, AL, USA; No Copyright; Avail: CASI; A02, Hardcopy

The methods and results presented in this summary address the thermographic identification of interstitial leaks in the Space Shuttle Main Engine nozzles. A highly sensitive digital infrared camera is used to record the minute cooling effects associated with a leak source, such as a crack or pinhole, hidden within the nozzle wall by observing the inner 'hot wall' surface as the nozzle is pressurized. These images are enhanced by digitally subtracting a thermal reference image taken before pressurization, greatly diminishing background noise. The method provides a nonintrusive way of localizing the tube that is leaking and the exact leak source position to within a very small axial distance. Many of the factors that influence the inspectability of the nozzle are addressed; including pressure rate, peak pressure, gas type, ambient temperature and surface preparation.
Author
Nondestructive Tests; Thermography; Background Noise; Nozzle Walls

20000067649 Boeing Co., Canoga Park, CA USA
Laser Brazing of High Temperature Braze Alloy
Gao, Y. P.; Seaman, R. F.; McQuillan, T. J.; Martiens, R. F.; [2000]; In English, Apr. 2000, Chicago, IL, USA
Contract(s)/Grant(s): NAS8-45000; No Copyright; Avail: Other Sources; Abstract Only

The Space Shuttle Main Engine (SSME) consists of 1080 conical tubes, which are furnace brazed themselves, manifolds, and surrounding structural jacket making almost four miles of braze joints. Subsequent furnace braze cycles are performed due to localized braze voids between the coolant tubes. SSME nozzle experiences extremely high heat flux (180 mW/sq m) during

hot fire. Braze voids between coolant tubes may result in hot combustion gas escape causing jacket bulges. The nozzle can be disqualified for flight or result in mission failure if the braze voids exceed the limits. Localized braze processes were considered to eliminate braze voids, however, damage to the parent materials often prohibited use of such process. Being the only manned flight reusable rocket engine, it has stringent requirement on the braze process. Poor braze quality or damage to the parent materials limits the nozzle service life. The objective of this study was to develop a laser brazing process to provide quality, localized braze joints without adverse affect on the parent materials. Gold (Au-Cu-Ni-Pd-Mn) based high temperature braze alloys were used in both powder and wire form. Thin section iron base superalloy A286 tube was used as substrate materials. Different Laser Systems including CO2 (10.6 micrometers, 1kW), ND:YAG (1.06 micrometers, 4kW). and direct diode laser (808nm. 150W) were investigated for brazing process. The laser process variables including wavelength. laser power, travel speed and angle of inclination were optimized according to bead geometry and braze alloy wetting at minimum heat input level, The properties of laser brazing were compared to that of furnace brazing. Microhardness profiles were used for braze joint property comparison between laser and furnace brazing. The cooling rate of laser brazing was compared to furnace brazing based on secondary dendritic arm spacing, Both optical and Scanning Electron Microscope (SEM) were used to evaluate the microstructures of the braze materials and tube substrate. Metallography of the laser braze joint was compared to the furnace braze. SEM Energy Disperse X-Ray Spectra (EDX) and back scattered imaging were used to analyze braze alloy segregation. Although all of the laser systems, CO2, ND:YAG, and direct diode laser produced good braze joint, the direct diode laser was selected for its system simplicity, compactness and portability. Excellent laser and braze alloy coupling is observed with powder alloy compared to braze alloy wire. Good wetting is found with different gold based braze alloys. The laser brazing process can be optimized so that the adverse affect on the parent materials can be eliminated. Metallography of the laser braze joint has shown that quality braze joint was produced with laser brazing process. Penetration of the laser braze to the substrate is at neglectable level. Zero penetration is observed. Microstructure examinations shown that no observable changes of the microstructure (grain structure and precipitation) in the HAZ area between laser braze and furnace braze. Wide gaps can be laser brazed with single pass for up to 0.024 inches. Finer dendritic structure is observed in laser brazing compared with equiaxial and coarser grain of the furnace brazing microstructure. Greater segregation is also found in the furnace braze. Higher hardness of the laser braze joint comparing to furnace braze is observed due to the fast cooling rate and Finer microstructure in the laser brazing. Laser braze joint properties meet or exceed the furnace joint properties. Direct diode laser for thin section tube brazing with high temperature braze alloys have been successfully demonstrated. The laser's high energy density and precise control has shown significant advantages in reducing process heat input to the substrates and provide high quality braze joints comparing to other localized braze process such as torch, TIG, and MPTA processes. Significant cost savings can be realized particularly with localized braze comparing to a full furnace braze cycle.
Author
Brazing; Heat Resistant Alloys; High Temperature; Furnaces; Semiconductor Lasers

Subject Terms

Corporate Sources

Document Authors